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SALT-INDUCED CHANGES IN PHYSIOLOGICAL PARAMETERS OF ORIGANUM MAJORANA: A SYSTEMATIC INVESTIGATION

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Abstract

This study investigates the effects of varying concentrations of sodium chloride (NaCl) on the growth and physiological parameters of *Origanum majorana L*., commonly known as *marjoram. Marjoram*, a perennial herb with culinary and medicinal significance, was subjected to different levels of salinity stress to assess its adaptability and response to adverse environmental conditions. Healthy marjoram plants were selected, transplanted into pots, and exposed to NaCl concentrations of 0 gm (control), 2 gm, 3 gm, and 4 gm per 100 ml of water. The study measured root and shoot lengths, observed changes in leaves, seeds, and buds, and evaluated fresh and dry weights, as well as chlorophyll content. Results indicate that increased NaCl concentrations negatively impacted root and shoot growth, with higher salt levels leading to inhibited development. The chlorophyll content, a crucial indicator of plant health, also decreased with rising salt concentrations. The findings suggest that salinity stress adversely affects the growth and physiological parameters of marjoram. This research contributes valuable insights into the adaptive capacity of *Origanum majorana L*. under salt stress, providing information relevant to agricultural practices and environmental conditions. Understanding how marjoram responds to salinity stress is essential for optimizing its cultivation in regions facing increasing salinity issues.

INTRODUCTION

Origanum majorana L. is a small tender Bush which is a perennial herb that grows up to a height of approximately 1 foot. It is a plant native to Asia but it has also been found growing naturally in European countries where it is among one of the favorite ingredient of both Romans and Greek cuisines.

This plant in Hindi and marathi is commonly known as marva. The plant has multiple branches which are square, tiny and Oval in shape with leaves having Gray texture that may be fuzzy.

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Scientific classification	
Kingdom	Plantae
Phylum	Angiosperms
Class	Dicotyledonae
Order	Lamiales
Family	Lamiaceae
Genus	*Origanum*
Species	*O. majorana*

The buds of this plant have a knot like structure that opens to form a cluster of pinkish or whitish flowers. The branches and leaves of this plant are put under steam distillation for extracting a very important essential oil which is warm and spicy with a little peppery aroma and have woody and nutty fragrance which is very soothing calming and comforting. (Cano et al., 2004)

The leaves of this plant are simple and 0.5 to 1.5 centimeter long and 0.2 to 0.8 centimeter in width with an obtuse apex, complete margin, reticulate venation and symmetrical but are tapering at the base. The microscopy of the leaves have revealed that that the leaves are dorsiventral in nature. Both the leaf surfaces shows presence of a large number of try Combs, dice and a thin walled baby epidermis. The type trichomes that cover the leaf surface uniseriate, multicellular, pointed and thin walled. In the midrib portion of the leaf, the epidermis is further followed by Colin, and Xylem phloem that is vascular bundles. Where is the miso fill cells or the mesophyll layer is composed of spongy parenchyma and palisade cells only. (Pimple et al., 2012)

Marjoram, a key member of the mint family, holds economic and pharmaceutical promise due to its potent antimicrobial and antioxidant properties. Rich in flavonoids, essential oils, and phenolic compounds, it has potential in various industries (Şahin et al., 2004; Daferera et al., 2000; Sellami et al., 2009). Natural antioxidants in marjoram, unlike synthetic counterparts like BHA and BHT, attract attention for promoting human health and preventing diseases, including cancer (Tapiero et al., 2002; Sellami et al., 2009). Despite extensive studies on aromatic herbs, research on sweet marjoram production within integrated agriculture-aquaculture systems remains limited (Edris et al., 2003; FAO, 2005a, 2005b).

Tabanca et al. (2004) found O. majorana L. and O. × majoricum cambess plants exhibited essential oil composition ranging from 0.68-2.26%, dependent on genotype, collection region, and date. Lamiaceae family plants' elevated phenolic and flavonoid levels are attributed to nutrient-rich soil and adequate moisture (Omer, 1999). Marjoram, widely distributed in the Mediterranean, primarily contains essential oils, polyphenols, flavonoids, sterols, triterpenes, alkaloids, coumarins, tannins, and saponins (Della et al., 2019). Essential oil constituents include terpineol (29.6%), 2-carene (20.1%), camphene (13.4%), and α-pinene (7.9%), exhibiting antibacterial effects (Della et al., 2019). Phenolic compounds like dihydroxy acid, gallic acid, chlorogenic acid, and caffeic acid are also prominent (Mona, 2011; Ribes et al., 2019).

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O. majorana is an important herb which comprises of various many important components such as certain essential oils and phenolic compounds which are extracted from the leaves as well as flowers and stem and are usually used for cooking purpose as a spice and condiment (Jiang et al., 2011). Polyphenols have a strong antioxidant effect hence it is generally used as a food additive. (Bouyahya., 2021). *O. majorana* can also be used for preparing a tea and it can also be used as a medicine for balancing the hormonal levels among women (Haj et al., 2016). The plant has also been reported to contain several other components such as many essential amino acids, carbohydrates and vitamin C which have been extensively used in the food industries. (Hossain et al., 2011, Pimple et al., 2012).

Three main varieties of marjoram are commonly cultivated in herb gardens. These three are sweet marjoram (Origanum marjorana), pot marjoram (Origanum onites), which has a more pronounced flavor than sweet marjoram, and wild marjoram (Origanum vulgare), which is commonly called oregano. There are several named varieties of oregano as well, including Italian oregano, and Sicilian oregano. All varieties of marjoram are cultivated for their culinary use, as well as for their enjoyable fragrance.

Marjoram, sensitive to cold and freezing, thrives as an annual in cooler climates, requiring full sunlight and well-draining soil. It adapts to various soil types but favors a pH between 6.7 and 7.0. Begin growing marjoram indoors in late winter or early spring for an early start, planting seeds just beneath the soil surface. Once frost risk passes, transplant robust seedlings to the garden. Alternatively, cultivate marjoram in indoor containers or a greenhouse for flexibility and protection from harsh weather conditions.

Marjoram, a cold-sensitive herb, is best grown as an annual in cool climates, thriving in full sunlight and well-draining soil with a pH of 6.7 to 7.0. It accommodates various soil types but prefers good drainage. Start by growing seeds indoors in late winter or early spring, transplanting healthy seedlings to the garden after the threat of frost has passed. Alternatively, cultivate marjoram in containers indoors or a greenhouse for adaptability and protection from harsh weather.

Over 20% of globally irrigated land faces escalating salinity issues, exacerbated by dynamic climate changes and water overexploitation for irrigation. This abiotic stress significantly impairs agricultural productivity. Elevated soil or irrigation water salinity disrupts plant metabolism, causing cellular imbalance and impacting vital physiological and biochemical processes. Salinity induces osmotic stress and ionic toxicity, impeding plant growth, dry matter distribution, seed germination, photosynthesis, and crop yield (Hasanuzzaman et al., 2013).

The high amount of of soluble salts in excess in the soil, particularly common salt i.e., NaCl, has been found to cause three major types of stress conditions in among the plant community, and these are osmotic stress, ionic stress, and oxidative stress. The above said stresses causes a reduction in absorption and induces a heavy outflow of water molecules and potassium ions in the plant cells, which results in water, as well as nutritional disbalances. The aims and objectives of this study are to test the effect of NaCl on the growth of the selected plant.

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2. MATERIAL AND METHODS

2.1. Selection of plants: Healthy plants of Origanum majoram were selected from a nearby nursery. Almost identical plants were selected for the experiment nhaving almost same length and branching were selected.

2.2. Transfer of plants: The plants came in black polybags, the plants were carefully transferred to pots of appropriate size. But before transplanting the length of roots and shoots was measured. Four plants were taken and labelled as A, B, C and D.

2.3. Salinity management in the plants: Plants underwent water treatments with varying NaCl concentrations. Plant A, the control, received normal drinkable water, avoiding distilled water to ensure essential nutrients. Plants B, C, and D were exposed to increasing salt concentrations: 2 gm, 3 gm, and 4 gm per 100 ml of water, respectively. The consistent concentrations were maintained despite water percolation. Watering occurred every two days with the specified salt concentration, creating a controlled environment to assess the impact of salinity on plant growth and development.

2.4. Measurement of length of root and shoot: The root and shoot length was measured using an inchitape two times. One before transplantation and second when the plants gave the results I., within one week.

2.5. Observation of leaves: The leaves were observed every day for colour change and surface area change

2.6. Observation of seeds and buds: The seeds and buds were observed for changes daily for seven days.

2.7. Measurement of fresh and dry weight: the plant was uprooted and most of the soil was removed from the roots and was weighed on the weighing balance. The plants were then air dried in oven for 2 hrs and checked for moisture. They were crushed into powder form and weighed for their dry weight.

2.8. Measurement of chlorophyll: For the measurement of chlorophyll content, the fresh and final leaves were sent to HAU, Hisar. The readings were taken at 650nm and were further converted into mg cm-2.

3. RESULTS

3.1. Root length: The experiment measured the initial and final lengths of plant roots (in cm) under different salt concentrations. Plant A, the control, exhibited root growth from 15 cm to 20 cm, indicating a positive response to normal water. Plant B, with a low salt concentration of 2 gm per 100 ml, showed growth from 17 cm to 21 cm. However, higher salt concentrations negatively impacted root growth. Plant C, treated with 3 gm of salt, experienced limited growth, increasing from 13 cm to 15 cm. Plant D, exposed to 4 gm of salt, demonstrated the most inhibited growth, with the root length progressing only from 11 cm to 12 cm. These findings suggest a correlation between increased salt concentration and reduced root development.

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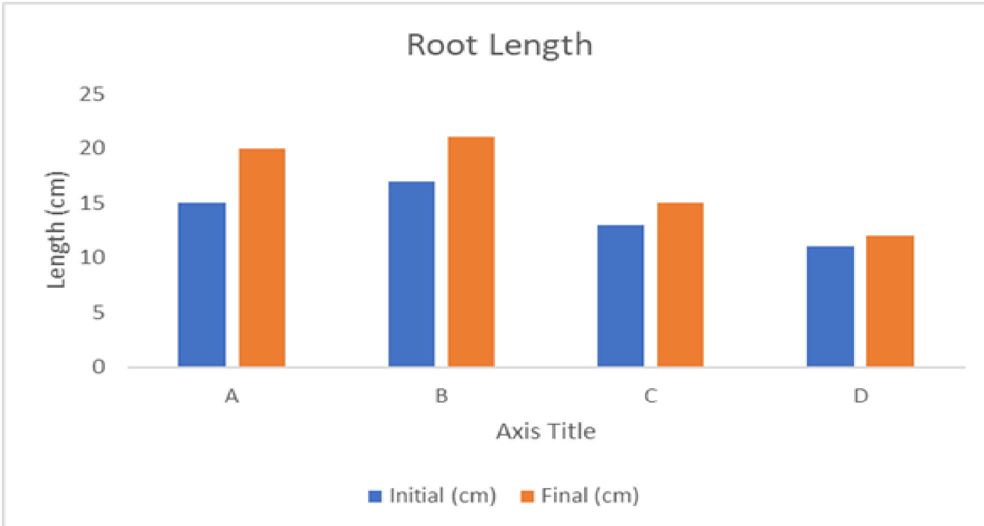

Figure 1: Chart showing results of before and after salt addition on root length

3.2. Shoot length

Fig. 2 illustrates the initial and final shoot lengths (in cm) of different plants subjected to varying salt concentrations. Plant A, the control, exhibited robust shoot growth, increasing from 29 cm to 35 cm. Plant B, exposed to a low salt concentration of 2 gm per 100 ml, showed a moderate increase from 33 cm to 36 cm. Plants C and D, treated with higher salt concentrations of 3 gm and 4 gm per 100 ml, respectively, displayed limited shoot growth. Plant C's shoot length increased from 34 cm to 37 cm, while Plant D exhibited a constrained growth, progressing from 28 cm to 30 cm. These results suggest that excessive salt concentrations may have a negative impact on shoot development in plants.

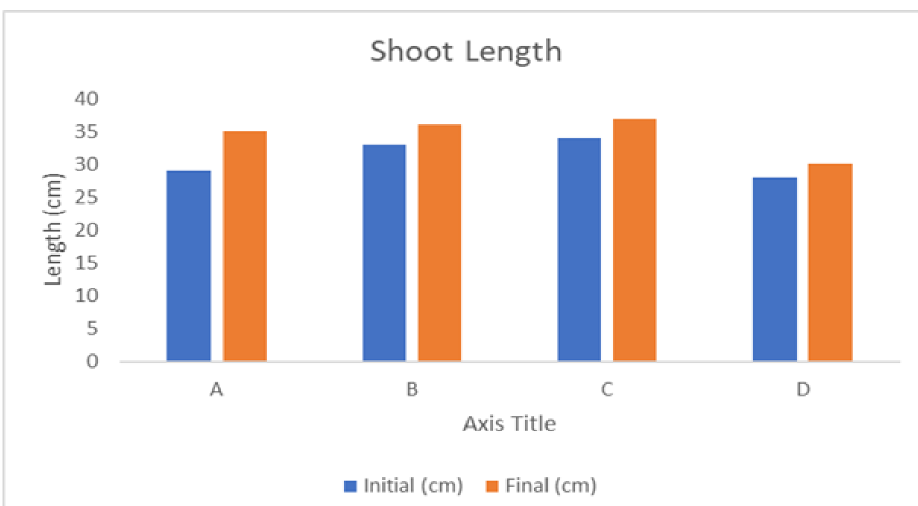

Figure 2: Chart showing results of before and after salt addition on shoot length

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3.3. Chlorophyll content

The observed dataset reveals the initial and final chlorophyll content measured in milligrams per square centimeter (mg cm^-2) for four distinct items labeled A, B, C, and D. At the outset, item A displayed an initial chlorophyll content of 0.32 mg cm^-2, which decreased to 0.22 mg cm^-2 by the end of the observation period. Similarly, item B started with an initial chlorophyll content of 0.29 mg cm^-2 and concluded with a final content of 0.18 mg cm^-2. Item C exhibited an initial value of 0.30 mg cm^-2, decreasing to 0.13 mg cm^-2 in the final measurement. Notably, item D had an initial chlorophyll content of 0.35 mg cm^-2, which significantly reduced to 0.08 mg cm^-2 by the end of the observation period.

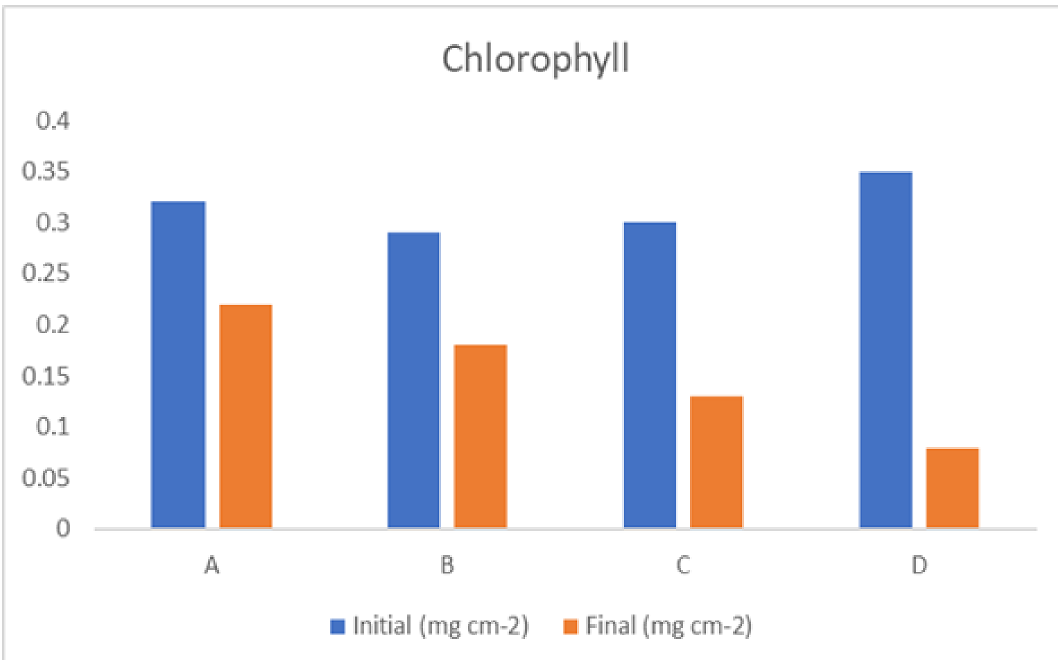

Figure 3: Chart showing results of before and after salt addition on chlorophyll content

3.4. Fresh and dry weight

The investigation also focused on the measurement of both fresh weight and dry weight for each item. Fresh weight represents the initial mass of the items, while dry weight reflects the weight after the removal of moisture. The study revealed the following results:

Item A had a fresh weight of 158 and a corresponding dry weight of 98. Item B showed a fresh weight of 304, with a dry weight of 129. For item C, the fresh weight was 257, and the dry weight was 196. Lastly, item D exhibited a fresh weight of 182 and a dry weight of 108.

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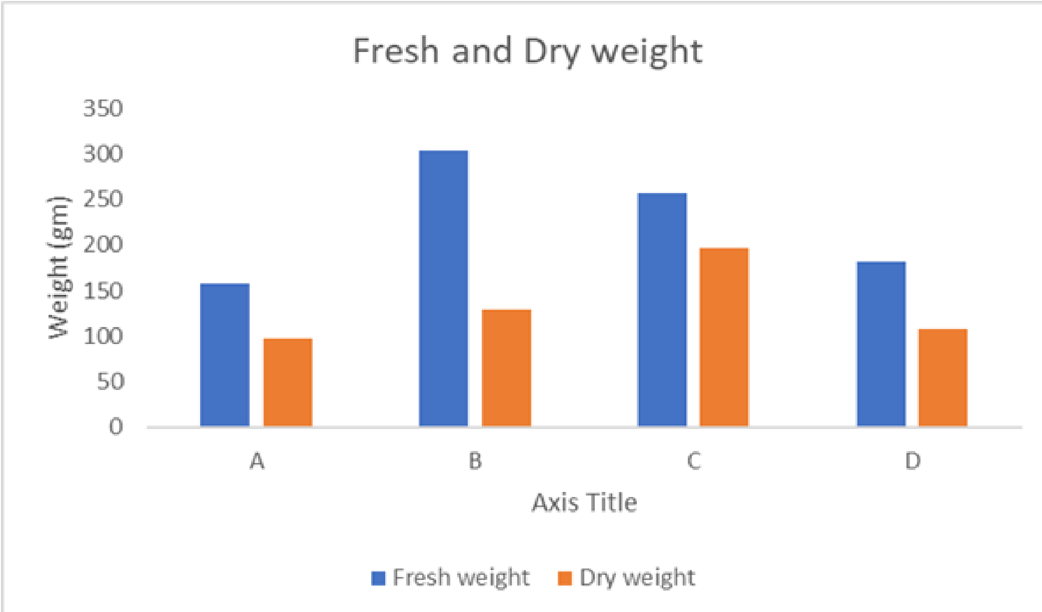

Figure 4: Chart showing results of before and after salt addition on fresh and dry weight

DISCUSSION

Baatour et al. (2011) looked into the effects of stress generated by salt on the output of essential oils and fatty acid content of the aerial portions of two marjoram cultivars. Plants with six leaves each were chosen, and a 75mM NaCl solution was applied to them. The plants' shoot section, or aerial component, growth was slowed down by the salt treatment. The findings also revealed that the Tunisian variety (TV), as opposed to the Canadian variety, had had a greater rise in fatty acid content as a result of salinity (CV). Under the impact of salt stress, CV also shown a rise in double-bond index (DBI) and revealed a decrease in the malondialdehyde concentration, whereas the case was discovered to be the opposite as It was seen on television.

A significant decrease in oleic and linoleic acids in TV had a major impact on the DBI, whereas linoleic acid was strongly stimulated in CV. In TV and CV, salt lowered and enhanced the output of essential oils, respectively. Trans-hydrate sabinene and terpinen-4-ol were the two main components of TV's essential oil, and they both significantly decreased when exposed to salt stress. The primary components of CV's essential oil, on the other hand, were sabinene and trans-hydrate sabinene, which under salt stress shown a considerable drop and increase, respectively. (2011) Baâtour et al.

In the present study, effect of NaCl concentration was studied on the plant of origanum majoram. The parameters which were measured were length of root and shoot before and after addition of salt. Similarly, other parameter which were measured were chlorophyll content and fresh and dry weight of the plant.

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From the above study it was revealed that with increasing concentration of salt all the growth parameters were adversely affected.

Summary

The above study is carried on the plant of Origanum majoram to determine the concentration of NaCl on the growth parameters of the plant. The plants were bought from a nearby nursery and were transplanted in pots of appropriate size. The plants were watered regularly as per mentioned above in the third chapter material and methods and the effect of different salt concentrations were observed and recorded to present the results.

CONCLUSION

From the above study it can be concluded that with increasing g salt concentration, all the studied parameters are adversely affected. There is retardation in growth of root and shoot. Leaves also show fall in chlorophyll content which is similar to senescence. Also the fresh and dry weight was measured which showed that weight of the plant also decreases as compared to control.

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